Standard Spacecraft Interfaces and IP Network Architectures

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AGENDA

- Overview
- Objectives and Goals
- Prototype Software
- Prototype Hardware
- Summary – So What!
- Future Work

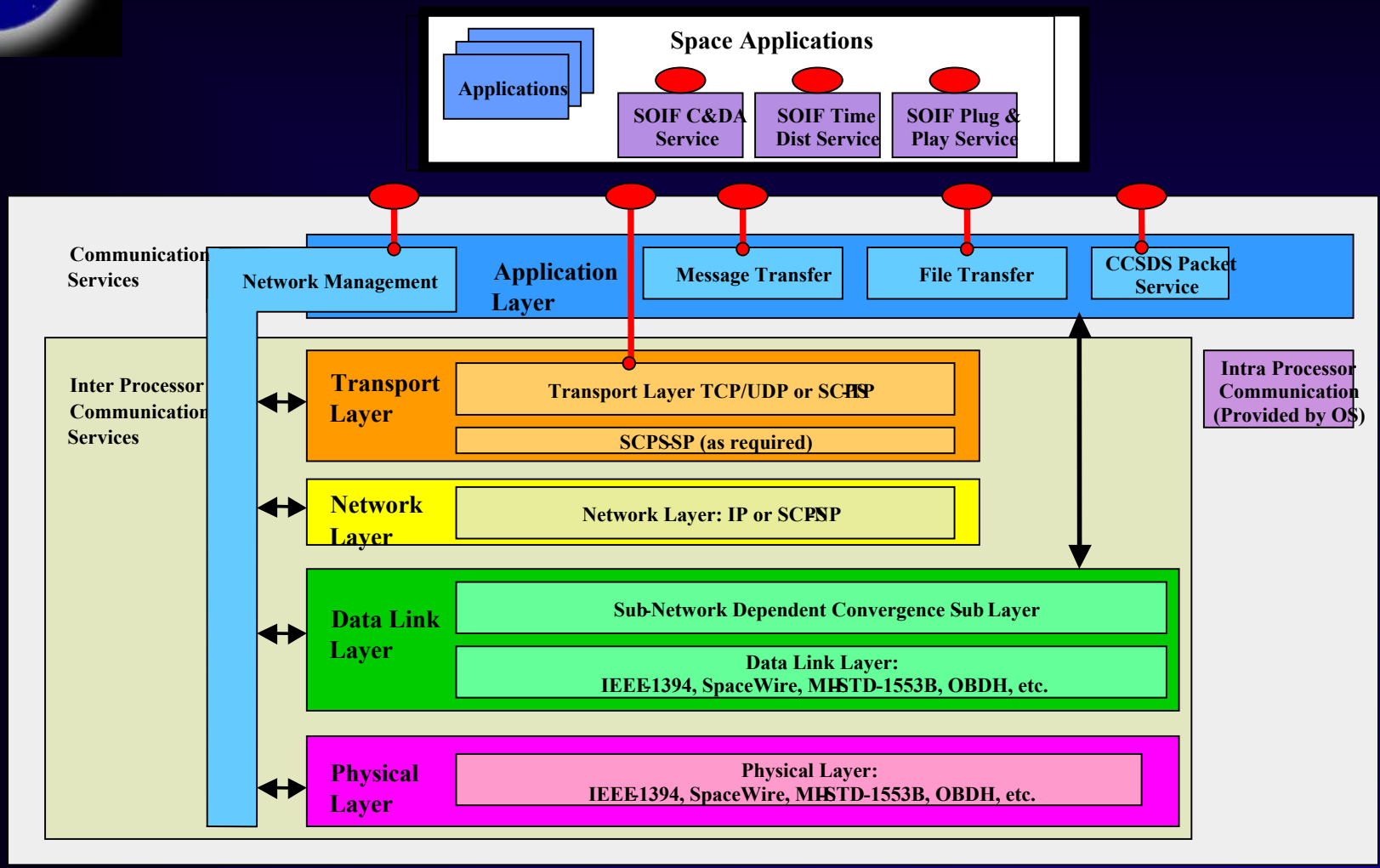
Overview

- SOIF standardization of flight networks will enable interoperable space hardware components
  - Reduces development and test costs
- Networks used on current missions (JWST, NPOES, SDO, GLAST) are not interoperable leading to duplication of effort
- GSFC Flight Ethernet Prototype, based on SOIF implementation model, will demonstrate benefits of an interoperable network
- Prototype will demonstrate Flight Ethernet, the baseline spacecraft bus for the GPM spacecraft

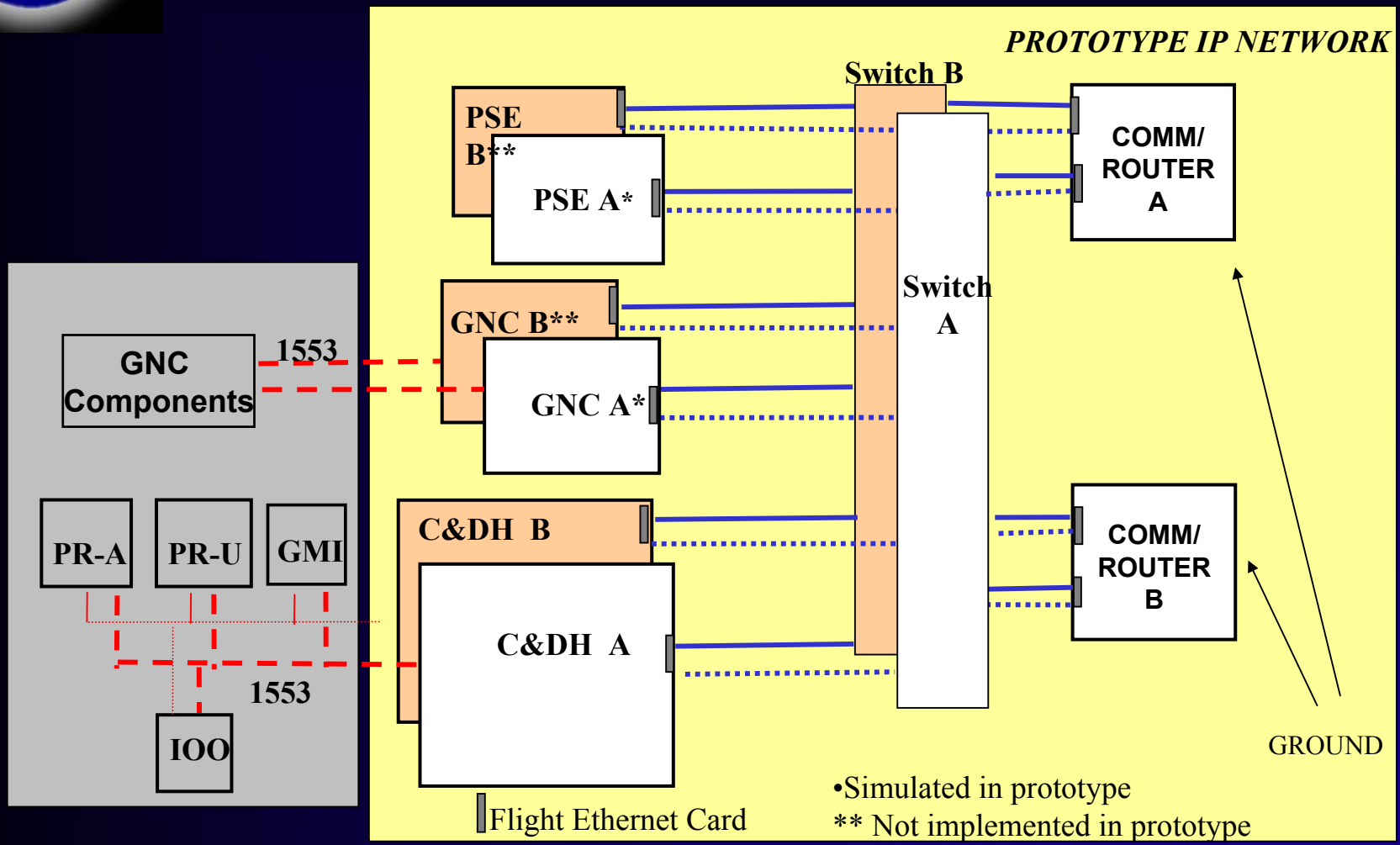
Objectives and Goals

- Long-term goal:
  - Develop an onboard IP network for Ethernet using the SOIF implementation model
  - Concentration on Network Layer and Convergence Sub-Layer
- Prototype goals:
  - Verify Flight Ethernet NIC and Switch being developed by GSFC
  - Proof-of-concept of an IP/Ethernet spacecraft bus for GPM Mission

SOIF Implementation Model



Prototype in GPM Context



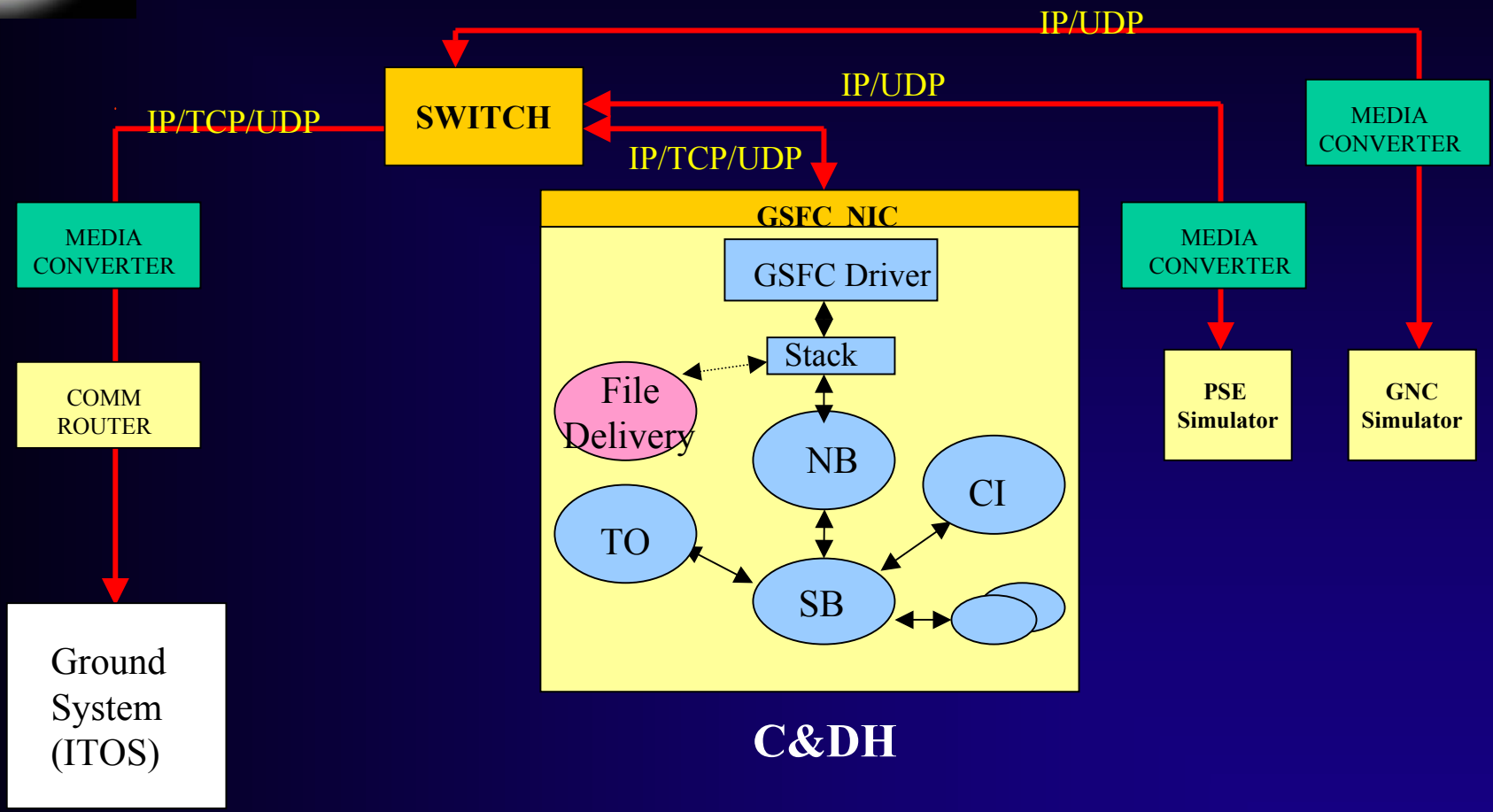
Prototype Software

- Network Bus application developed for inter-processor messaging (legacy software bus used for intra-processor messaging)
- Baseline UDP/IP
  - TCP not used - timeliness of reliability insufficient for mission critical, real-time applications
  - UDP enhanced by Fault-Tolerant messaging service in application layer - supports Network Bus
  - Standard IPv4 protocol stack used – RTEMS Operating System has BSD stack

Prototype Software

- Integrate simple convergence sub-layer
  - Required for flight-level QoS such as reliability and schedule-driven communications
- Custom device driver for Flight Ethernet
  - Linux driver ported to RTEMS and customized for Flight Ethernet
  - Uses DMA for data transfer to/from NIC for better performance

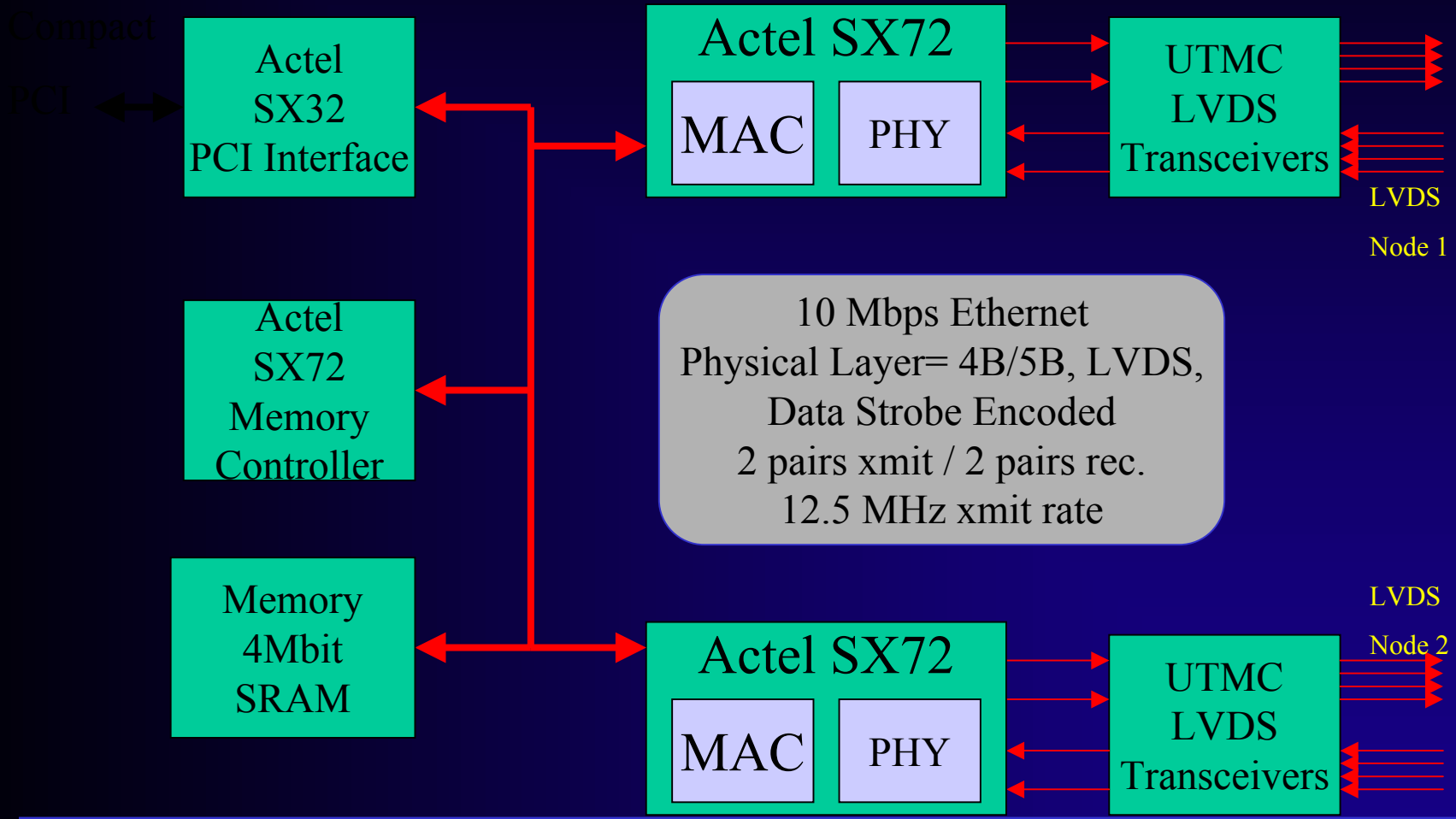
Flight Ethernet Prototype



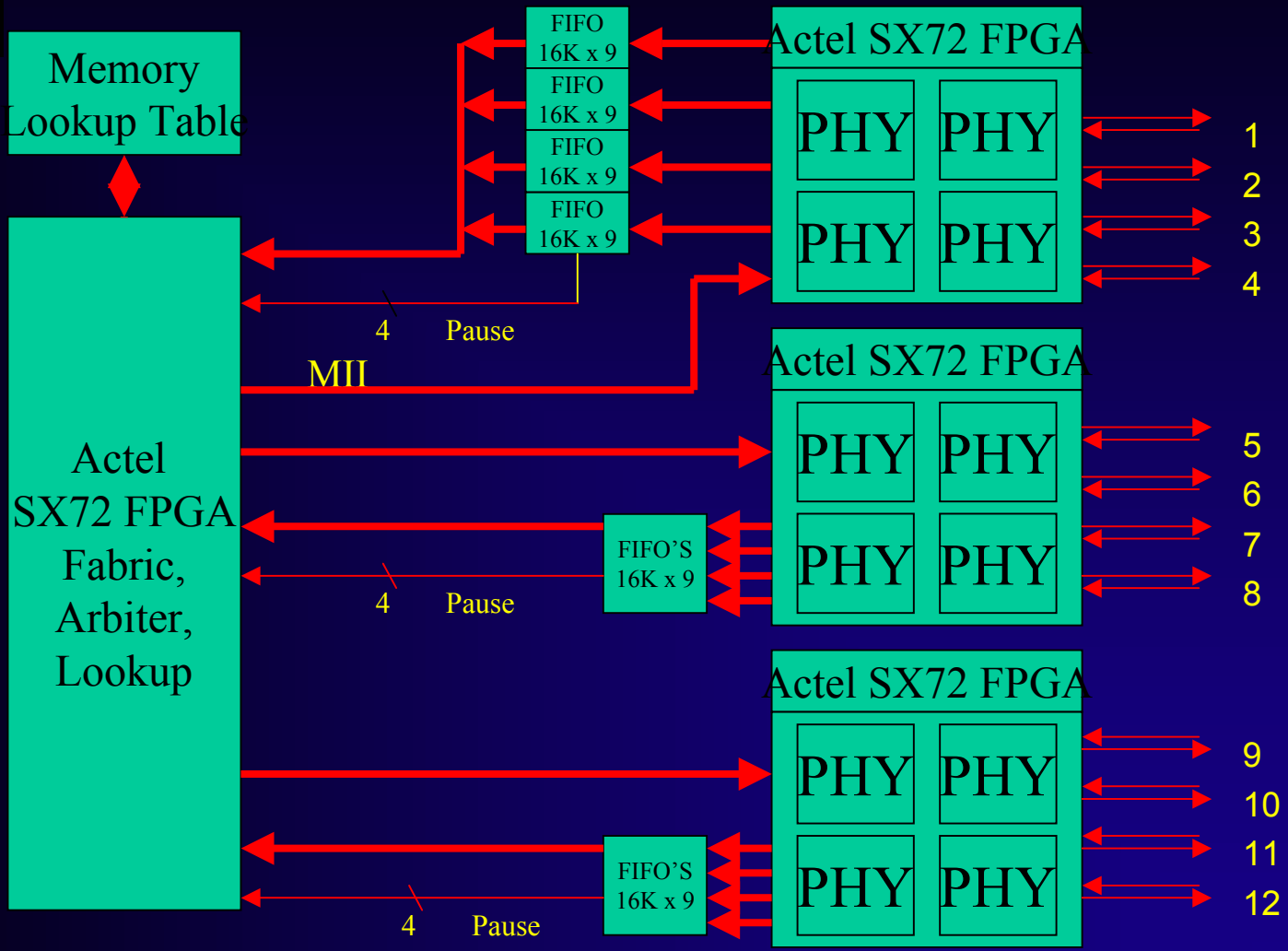
Prototype Hardware

- Switched full duplex topology
- Supports 10/100 Mbit Ethernet over twisted pair using a 12.5/125 Mbit DS Link encoded LVDS physical layer – media converter connects Flight Ethernet to 10/100-base TX
- NIC
  - Standard MAC core
  - Custom LVDS physical layer interface
- Switch
  - 12 port, fixed MAC address table
  - Supports Broadcast and Pause

Network Interface Card



12-Port Switch



Summary - So What!

- Effort to date has already shown cost savings
  - Commercially available network cards and standard device drivers enabled a quick testbed setup
    - Can be extended to development labs - commercial NICs and switches in system breadboards and ground test equipment
  - Ethernet Protocol engine saved $$ in development of Flight Ethernet NIC
    - Standard MAC core
    - Use of existing standards and methods as templates for flight applications
- Missions have a low-cost, standard solution for high-speed onboard networks
- Missions have interoperable space hardware components

Future Work

- Convergence sub-layer has challenges
  - QoS
    - Schedule-driven, isochronous communications
    - Reliability
    - Bandwidth management
  - Portability between:
    - operating systems
    - different data links
- Support for 100Mbps Flight physical layer
- Additional functionality
  - 1553 Standard Data Link
  - Time distribution
  - Standard Messaging Service

• NASA DATA SYSTEM STANDARDS PROGRAM •

1. Interplanetary Internet: An Architectural Framework for Space Internetworking: Adrian Hooke
2. User Data Services for Internet Based Spacecraft Applications: Joe Smith
3. CCSDS File Delivery Protocol (CFDP): Tim Ray
4. Internet Protocol Based Standards for Spacecraft Onboard Interfaces: Joe Smith
5. Standard Spacecraft Interfaces and IP Network Architectures: Jane Marquart
6. Standard Transport and Network Capabilities: Bob Durst
7. Next Generation Space Internet: Standards and Implementation: Keith Scott
8. Secure Space Networking: Howie Weiss
9. Delay Tolerant Networking: Scott Burleigh
10. CCSDS Link Layer Protocol Suite: Greg Kazz